Memorandum

U.S. Department of Transportation
United States Coast Guard

Subject: NATIONAL CANCER INSTITUTE'S CANCER MORTALITY STUDY OF COAST GUARD MARINE INSPECTORS

Date: 3 August 1987
16616/70

Reply to Attn. of: G-MTH-1: 71577

From: Project Manager, NCI Study

To: MI Program Manager

1. In 1981 the National Cancer Institute (NCI) initiated a cancer mortality study, at the Coast Guard's request, to determine whether marine inspectors are at higher risk than other Coast Guard personnel to certain cancers normally associated with chemical overexposures. We were aware that marine inspectors must enter cargo tanks, void spaces, pumprooms, and other confined spaces where they would encounter vapor residues from various chemicals and petroleum products. The long-term health effects for many of these products are well documented. Our concern was that years of exposure to these products, even at relatively low concentrations, could lead to chemically induced disease or cancer. NCI provided the funding for this six year study which was recently completed. Work history records and fitness reports were obtained on about 1800 Coast Guard officers engaged in marine inspection between 1942 and 1970 and for a comparison group of 1900 officers who were never marine inspectors. The "vital status" of these personnel (whether they were alive or deceased, and if deceased, cause of death) was followed until approximately 1982. Potential exposure to chemicals for each inspector was assessed by Coast Guard personnel involved in the study based on geographical area and actual duties performed. The principal researcher for this study was Dr. Aaron Blair of NCI, an experienced occupational epidemiologist (a scientist specializing in disease trends caused by chemicals, fibers, particulates, etc. in an industrial work environment).

2. The study concluded that there was excess mortality among inspectors from cancers of the colon, liver, skin, and lymphatic and hematopoietic (blood) system, particularly leukemia, which could be related to organic solvents and other chemicals to which they came in contact while inspecting ships and barges. The risk of leukemia, cancer of the liver and cirrhosis of the liver increased with level of exposure to chemicals, further suggesting that occupational exposures may play an important role. These results indicate that programs to control exposures as well as effective medical monitoring programs for early detection of disease and cancer are necessary for marine inspectors.

3. Since most chemicals have relatively long latent periods between exposures and development of cancer (benzene induced leukemia is an exception), much of the mortality cited in this study probably resulted from earlier exposures when the chemical trade was fairly limited compared to today. The variety of chemicals being shipped over the past 10-15 years has also increased dramatically as many specialty products have begun to move in smaller lots on tank vessels. Many chemicals have demonstrated long-term health effects which

can occur from repeated exposure to their vapors. Another potentially serious problem is chemical interactions within the body from multiple exposures, a fairly common occurrence during sequential inspection of tanks or void spaces containing residues. All of these factors suggest we may have a more serious problem in future years when the effects from these newer exposures manifest themselves. On the positive side, I would expect that vapor concentrations to which inspectors are exposed today would be lower because of better training of marine chemists and their use of more sophisticated instrumentation. However, there are still many products shipped in bulk, particularly mixtures, for which permissible exposure levels have yet to be established or equipment available to detect their vapors.

4. Dr. Blair has recommended a follow-up study to obtain information on alcohol use and to better characterize exposures by performing some air monitoring studies. Again, this would be at NCI expense and our contribution would be our time and assistance. Although high alcohol consumption could account for the excess of cirrhosis of the liver, Dr. Blair believes it is more likely, based on his review of the data, that alcohol is not the main cause and only contributed in a synergistic manner to the destructive action of chlorinated solvents on the liver. Further study should answer this question. I recommend we proceed with the follow-up study to dispel the alcohol factor and refine the exposure data to some degree.

5. Dr. Blair informally discussed the study with a small group of Coast Guard personnel on 25 June. He has indicated he would be happy to make a formal presentation to Coast Guard and discuss follow-up plans. I recommend we take him up on this offer as it would be a good opportunity to hear the details of the study (in non-technical terms) and its implications for future health problems. Dr. Blair plans to submit the NCI report to the American Industrial Hygiene Association for publication. I and several other Coast Guard personnel who assisted him with the study are listed as co-authors. Clearance is therefore requested for publication of the report.

6. In summary the NCI study is further supporting evidence of what we have suspected for years - overexposures to chemicals and certain petroleum products on a fairly routine basis will eventually result in an excess of disease or cancer. Programs to control these exposures are slowly taking shape but are not getting the full attention and support they need. Failure to take positive action in terms of resources to develop and support a meaningful program will result in further exposures to health-threatening chemicals by our people.

Michael Morrissette

MICHAEL MORRISSETTE

Encl: (1) NCI report

cc: G-MTH G-MVP
G-MVI G-MP
G-MPS G-CSP
G-MER G-KOM

Memorandum

U.S. Department of Transportation
United States Coast Guard

Subject: PRESENTATION BY DR. BLAIR, NATIONAL CANCER INSTITUTE, ON THE RESULTS OF A CANCER MORTALITY STUDY OF COAST GUARD MARINE INSPECTORS

Date: 24 September 1987
16616/70

Reply to Attn. of: G-MTH-1: 71577
Mr. Morrissette

From: Project Manager, NCI Study

To: Marine Inspection Program Manager

1. I have arranged for a presentation by Dr. Aaron Blair on the results of NCI's study on marine inspectors. He is scheduled to speak at 1300 on 7 October in room 1301. The presentation will last about 45 minutes.

2. Dr. Blair will describe the study method of using work history records to track disease trends and will provide an analysis of the data comparing mortality rates for cancers and other causes of death among inspectors and noninspectors. The study has uncovered some interesting trends with respect to occupational chemical exposures and certain cancers. In an earlier briefing Dr. Blair suggested some follow-up research he felt would refine the study results further; he also will discuss his recommendations in this area.

3. This study represents a substantial effort on NCI's (and Coast Guard's) part to determine whether marine inspectors are at higher health risk than other Coast Guard personnel. I believe you will find the presentation very informative and worth your time.

M D Morrissette

M. D. MORRISSETTE

Copy: G-dM
G-MTH
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DEPARTMENT OF HEALTH & HUMAN SERVICES

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June 26, 1987

Mike Morrissette
Hazardous Materials Branch
U.S. Coast Guard
2100 Second Street, S.W.
Washington, D.C. 20593

Dear Mike:

Enclosed is a copy of the marine inspector paper. I have incorporated all comments provided by the coauthors. The paper has been cleared for publication at NCI. When I receive word you have obtained similar clearance at the Coast Guard, I plan to send it to the American Industrial Hygiene Association Journal for publication. In the meantime would you please sign the copyright form and circulate it to Rex and Tom for their signatures also.

Our meeting on June 25 was very profitable. I think a followup case-control study to obtain information on alcohol use and additional exposure information would be valuable.

I would be happy to make a formal presentation of the study results to the Coast Guard and to discuss followup plans if you think this would be useful.

Sincerely,

Aaron Blair

Aaron Blair, Ph.D.
Occupational Studies Section
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Enclosure

6/11/37

Mortality among United States Coast Guard marine inspectors

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Mortality among United States Coast Guard marine inspectors

Abstract

Marine inspectors of the U.S. Coast Guard inspect merchant vessels for integrity of the hull, machinery, and equipment. During these inspections they enter cargo tanks, void spaces, cofferdams, and pumprooms and may encounter various chemicals including acrylonitrile, carbon tetrachloride, ethylene dibromide, ethylene dichloride, benzene, gasoline, styrene, tetrachloroethylene, and trichloroethylene. As a result of these potentially hazardous exposures, the National Cancer Institute and the U.S. Coast Guard initiated a mortality study of marine inspectors. Work history records and fitness reports were obtained on 1,767 persons engaged in marine inspection between 1942 and 1970 and for a comparison group of 1,914 officers who were never marine inspectors. Potential exposure to chemicals was assessed by one of the authors (RP) knowledgeable about marine inspection duties. Marine inspectors and noninspectors had a deficit in overall mortality compared to that expected from the general U.S. population (SMRs=79 and 63, respectively). Deficits occurred for most major causes of death including infectious and parasitic diseases, digestive and urinary systems, and accidents. Marine inspectors had excesses for cirrhosis of the liver (SMR=136) and motor vehicle accidents (SMR=107), and cancer of the lymphatic and hematopoietic system (SMR=157), while noninspectors had deficits for these causes of death (no deaths from liver cancer, and SMR = 53, 45, and 60, respectively). Comparison of mortality rates directly adjusted to the age distribution of the inspectors and noninspectors combined also demonstrated that mortality for these causes of death was greater among noninspectors (directly adjusted ratio ratios of 190, 145, and 198) for cirrhosis of the liver, motor vehicle accidents, and lymphatic and hematopoietic system cancer, respectively. SMRs rose with increasing probability of exposure to chemicals for motor vehicle accidents, cirrhosis of the liver and leukemia, suggesting that contact with chemicals during inspection of merchant vessels may be involved in the development of these diseases among marine inspectors.

Introduction

Marine inspectors of the U.S. Coast Guard inspect merchant vessels for the purpose of ascertaining the integrity of the hull, machinery, and equipment on board. During these inspections they enter cargo tanks, void spaces, cofferdams, and pumprooms, where they may encounter the hazards of oxygen deficiency and exposure to a variety of chemicals (1). These chemicals may include acrylonitrile, carbon tetrachloride, ethylene dibromide, ethylene dichloride, benzene, gasoline, styrene, toluene diisocyanate, tetrachloroethylene, and trichloroethylene (2). As a result of potential exposure to these and other chemicals, the Coast Guard established a Committee on Maritime Hazardous Materials to evaluate safety and environmental protection issues regarding the transport of hazardous materials. The Committee found little information available regarding the health of marine inspectors.

To obtain information on the health status of marine inspectors, the Coast Guard contacted the National Cancer Institute (NCI) to seek assistance in an in-depth analysis of the health status of marine inspectors. A collaborative study of the mortality experience of marine inspectors was undertaken and is presented here.

Methods

Marine inspectors were identified from annual registries of Coast Guard officers and enlisted personnel. Information available from the registries included name, rank, date of birth, service number, designator number, job

category and class year. For comparison, a group of nonmarine inspectors was selected and matched to marine inspectors on registry, rank, and year achieving that rank. For marine inspectors, personnel files at the National Personnel Record Center in St. Louis, MO, and at the U.S. Coast Guard Headquarters in Washington, D.C., were accessed to obtain demographic information and complete work histories. Information obtained included social security number, date of birth, race, sex, place of birth, type and date of termination from the Coast Guard, year of commission, and from semi-annual fitness reports information regarding each duty station including duties and dates of assignment. For nonmarine inspectors, demographic information and dates of entry and exit from Coast Guard personnel files were obtained, but detailed information on jobs and duties was not abstracted. The duty records for noninspectors, however, were scanned to make sure that they contained no marine inspection duties.

The cohort is composed of all persons performing marine inspection duties between 1942 and 1970 and suitable referents. Marine inspectors and referents were traced to January 1, 1980, to determine vital status. Vital status was ascertained through records from the Coast Guard personnel office, Veterans Administration, Social Security Administration, credit bureaus, and motor vehicle departments. For those deceased, death certificates were obtained and underlying causes of death were determined by an experienced nosologist, using the rules in effect at the time of death, and assigned rubrics of the 8th Revision of the International Classification of Diseases.

The level of exposure to chemicals while a marine inspector was estimated by one of the authors (RP) using information from description of duties, duty station, and rank. A four point rating scale (no exposure, low, moderate, and high exposure) was used. Nonexposed persons generally held administrative positions.

Low exposure was assigned to staff with duties that occasionally required vessel inspections. Moderate exposure was assigned to inspection duties that did not regularly include hull structures, and regular inspection of hull structures in geographic areas where chemicals were not major items of cargo. High exposure was generally reserved for persons peforming hull inspections at shipyards handling vessels transporting chemicals. A cumulative exposure score was calculated by summing the product of the four point rating scale and duration (months) in each job. All referents were classified as nonexposed. Since marine inspectors inspect ships and barges that haul a variety of products, and since it was not possible to reconstruct the actual exposure history of any particular subject, we could not assess exposure to specific chemicals. The proportion and mix of products conveyed by ships and barges varies somewhat by port. For example, ports along the Gulf Coast are major centers for the commercial shipping of petrochemicals while ports in the Northwest are major centers for wood products. Separate analyses were performed by geographic region.

Standardized mortality ratios (SMRs) were used to compare the mortality experience of marine inspectors with that of the total U.S. population and nonmarine inspectors. Person-year accumulation in the cohort began on January 1, 1942, (the initial year of cohort identification) when subjects first entered the Coast Guard (if after the cohort identification date), or upon first achieving a specified level or type of exposure, depending upon the particular analysis being undertaken. Person-year accumulation ceased at the closing date of the study (January 1, 1980), last date known alive, date of death, or date of achieving a higher exposure level (whichever was appropriate). Expected numbers for SMRs were calculated by applying 5-year age and calendar-year mortality rates from the appropriate race-sex group of the U.S. population to the person-year distribution of marine inspectors and referents (3). Ninety-five

percent confidence intervals were calculated using the method of Bailar and Ederer (4). A chi-square test was used to evaluate statistical significance of SMR trends (5). Mortality rates for inspectors and noninspectors were directly adjusted to the age and calendar-time person-year distribution of the combined cohorts to provide directly-adjusted rate ratios (rate among inspectors/rate among noninspectors X100) to avoid problems associated with comparing SMRs.

Results

Characteristics of marine inspectors and noninspectors are shown in Table I. The 3681 men in the study were composed of 1767 marine inspectors and 1914 Coast Guard officers who had never been engaged in marine inspection. The cohort was mostly white men (91%) with race unknown for 326 subjects (8%). In the analysis, those of unknown race were considered as white. A slightly smaller proportion of marine inspectors entered the Coast Guard before 1945 than did noninspectors (38% vs. 44%, respectively). Similarly, more marine inspectors were born after 1930 (28%) than noninspectors (24%). Tracing was very successful for marine inspectors (97%) and noninspectors (96%). There were a total of 852 deaths, 483 among marine inspectors and 369 among noninspectors.

Mortality for nonneoplastic causes of death is shown in Table II. The SMRs for all causes of death combined were significantly depressed among marine inspectors (SMR=79) and noninspectors (SMR=63). This was generally true for many major causes of death, although the deficits were generally greater among noninspectors. Significant deficits were observed for both groups for mortality from arteriosclerotic heart disease (SMRs of 77 for marine inspectors and 60 for noninspectors), vascular lesions of the central nervous system (SMRs of 71 and 44, respectively), and diseases of the genitourinary system (SMRs 20 and 12).

Other causes of death that showed deficits, but were not statistically significant in both groups, were infective and parasitic diseases (SMRs= 52 and 9), diabetes (SMR=23 and 37), rheumatic heart disease (SMRs= 90 and 31), all respiratory diseases (SMRs= 71 and 55), pneumonia (SMRs= 90 and 65), emphysema (SMRs= 65 and 48), diseases of the digestive system (SMRs= 90 and 47), all accidents (SMRs= 89 and 42), and suicide (SMRs= 46 and 64). Marine inspectors showed slight excesses for mortality from asthma (SMR=133), cirrhosis of the liver (SMR= 136) and motor vehicle accidents (SMR= 107), while noninspectors showed deficits (SMRs= 81, 53 and 45, respectively).

As with all causes of death, both marine inspectors and noninspectors had deficits for all cancers combined (SMRs = 88 and 75), although the deficit was statistically significant only among the noninspectors (Table III). No statistically significant excesses occurred for any specific cancer among inspectors or noninspectors. Lung cancer was significantly depressed among marine inspectors (SMR= 52). Marine inspectors had a slight elevation in mortality from cancers of the lymphatic and hematopoietic system (SMR= 157), while noninspectors had a deficit (SMR= 60). This excess among the marine inspectors was confined primarily to lymphosarcoma and reticulosarcoma (SMR= 175) and leukemia (SMR= 155). According to the death certificates, the histologic types of the leukemias among the marine inspectors were one lymphatic unspecified, three acute myeloids, and three acute unspecified. Both leukemias among the noninspectors were of the chronic lymphatic type. Other cancers which were slightly elevated among the marine inspectors, but not among the noninspectors, were colon (SMRs=144 and 78, respectively), rectum (SMRs=121 and 55), liver (SMRs=112 and 0 deaths), and skin (SMRs=158 and 95). Cancer of the brain was elevated among both marine inspectors (SMR=170) and noninspectors (SMR=136) as was cancer of the kidney (SMRs=106 and 103).

Comparison of directly-adjusted mortality rates for inspectors and noninspectors revealed similar patterns as when comparing SMRs. Using directly-adjusted rates, stomach cancer was greater among inspectors and larynx cancer was less frequent than among noninspectors in contrast to the pattern shown when comparing SMRs. Directly-adjusted rates for these sites, however, are based on small numbers.

Mortality for selected causes of death by cumulative level of exposure to chemicals is shown in Table IV. Mortality from cirrhosis of the liver, motor vehicle accidents, leukemia, and cancers of the rectum and liver increased with increasing level of cumulative exposure, although only the SMR trends for cirrhosis of the liver and motor vehicle accidents were significant. Since the type of cargo varies by port, analyses were also done by location of the duty station of the subjects. Although numbers were small, no clear pattern of risk for any particular cause of death emerged by geographic location of duty stations.

Discussion

When inspecting cargo vessels, marine inspectors may come in contact with a variety of chemicals including acrylonitrile, carbon tetrachloride, ethylene dibromide, ethylene dichloride, benzene, gasoline, styrene, toluene, tetrachloroethylene and trichloroethylene (2). Despite such potentially hazardous exposures, the overall mortality experience of marine inspectors is significantly better than the general population. This finding is not surprising given the professional nature of the Coast Guard Marine Inspection Service. The sociodemographic characteristics of the marine inspectors and the "healthy worker effect" seen in most studies of this design almost guarantee that the

overall SMR for these subjects will be less than 100. Causes of death typically affected by the healthy worker effect and showing deficits in this study include infective and parasitic diseases, diseases of the circulatory system, arteriosclerotic heart disease, emphysema, and pneumonia. Marine inspectors, however, had larger SMRs for most causes of death than noninspectors and a similar pattern occurred when directly-adjusted rate ratios were used for comparison. The reason for the greater deficit among noninspectors is unknown. Marine inspectors were slightly older than noninspectors but the difference was small. The socioeconomic standing of the group should be similar since both were primarily officers.

Marine inspectors had excess mortality from cirrhosis of the liver while noninspectors had a considerable deficit. It is known that chlorinated solvents and other chemicals are metabolized in the liver and are catalyzed by alcohol dehydrogenase (6). Since information on alcohol consumption was not available, it was not possible to directly assess alcohol and solvent effects independently. Cirrhosis of the liver has been induced experimentally in rodents by carbon tetrachloride (7,8), and cases following exposure have been reported in humans (9,10). That other chlorinated solvents (11) may have a similar effect is suggested by increased deposits of fat in the liver of rodents following exposure in tetrachloroethylene and chloroform, a feature prevalent in cirrhosis of the liver. Cirrhosis of the liver has been reported in a worker with no evidence of excessive intake of alcohol who was exposed to trichloroethylene and tetrachloroethane (12). Fatty change in the liver has also been reported among persons with occupational exposure to various organic solvents (13). Mortality studies of cohorts exposed to chlorinated solvents have generally not reported observed and expected deaths from cirrhosis of the liver (14-18), but a slight excess was noted among Oklahoma dry cleaners

(19). An association between chemical exposure and cirrhosis of the liver is suggested in this study by a significant exposure-response gradient where SMRs rise from 50 (a significant deficit) among the nonexposed, to 106 among those with < 130 working level-months, to 186 among those with ≥ 131 working level-months. Mortality from motor vehicle accidents was slightly elevated (SMR=107) among inspectors, but significantly depressed (SMR=45) among noninspectors. Mortality from accidents, however, also showed an exposure-response gradient with working level-months. Exposure to organic solvents is known to cause a variety of neurotoxic effects including dizziness, lightheadedness and incoordination (20). The effect on reaction time (21) may be particularly relevent regarding motor vehicle accidents. Excess of mortality from motor vehicle accidents has been noted among workers exposed to methylene chloride (18).

Deficits for mortality from arteriosclerotic heart disease and emphysema and cancers of the buccal cavity and pharynx, esophagus, and lung suggest that tobacco use among Coast Guard personnel is less than that among the general U.S. population. The deficit for arteriosclerotic heart disease among marine inspectors contrasts with well-known excesses caused by carbon disulfide (22) and a recent report of elevated mortality among rubber workers exposed to solvents, particularly ethanol and phenol (23). Inspectors, however, had slightly higher rates than noninspectors. The deficit for lung cancer is most striking among inspectors (SMR=52), while among non-inspectors the number of deaths from lung cancer is closer to that expected (SMR=81). Tobacco consumption may be less among inspectors than among noninspectors since the volatile nature of the many chemicals in ships precludes smoking, at least while inspecting vessels. We see no comparable mortality differences between inspectors and noninspectors for emphysema and cancer of the esophagus, causes of death as strongly affected by smoking as lung cancer.

Few cancers showed excesses among either inspectors o noninspectors. Cancers of the colon and rectum were slightly elevated among inspectors while among noninspectors there was a deficit for cancer of the rectum. Cancer of the rectum, but not the colon, showed the highest risk in the highest exposure category. Neither of these cancers has been clearly associated with occupational exposures, although a recent case-control study of colon cancer reported associations with solvents, fuel oils, and abrasives (24). Solvents and fuels are common cargoes for vessels inspected by the Coast Guard.

The slight excess for cancer of the liver among inspectors is based on small numbers. Liver tumors commonly develop in animals exposed to chlorinated solvents such as carbon tetrachloride, trichloroethylene, and tetrachloroethylene (25). There are a few reports of these cancers among persons with occupational exposures to some of these chemicals (14, 26-28). The risk of liver cancer rose with working-level months of exposure to chemicals to an SMR of 170 among those with a score of ≥131. This excess of liver cancer may, however, be related to alcohol use since it has been reported that this tumor is elevated among persons with alcoholic cirrhosis (29), and death from cirrhosis of the liver was also elevated among inspectors. The excess mortality from cancer of the skin among inspectors is of interest because of the potential for skin contact during inspection with many organic solvents which pass readily through the skin (25).

Inspectors as well as noninspectors showed slightly elevated mortality from cancer of the brain. Neither excess, however, was statistically significant. Cancer of the brain has developed in rodents exposed to acrylonitrile and has been reported among occupational groups exposed to various chemicals including organic solvents, vinyl chloride, lubricating oils, polycyclic aromatic hydrocarbons, and phenolic compounds (30). Among Coast Guard personnel, the

excess did not appear to be exposure-related since it occurred among those not exposed to chemicals as well as among the exposed. The excess could be due to diagnostic sensitivity bias since Coast Guard personnel have access to a comprehensive health care program. Such excesses have been noted among a variety of professional groups where diagositic sensitivity bias may operate.

Mortality from cancers of the lymphatic and hematopoietic system was elevated among inspectors, but not among noninspectors. Although this excess among inspectors was not statistically significant when the U.S. population served as the reference group, the SMRs among inspectors were approximately 2-1/2 times those seen among noninspectors. The risk of cancer of the lymphatic and hematopoietic system increased with increasing level of exposure from an SMR of 88 among the nonexposed, to an SMR of 152 among those with the heaviest exposure. This trend, however, was not statistically significant. Much of this trend for lymphatic and hematopoietic cancer is accounted for by the mortality pattern for leukemia where the SMRs rise from 80 to 105 to 184, respectively, across the three exposure categories. Inspectors may come in contact with a number of chemicals that may affect the lymphatic and hematopoietic system. Benzene is an established human leukemogen (31) and is one of the major organic solvents transported by ships and barges. Leukemia has also been reported among occupational groups exposed to tetrachloroethylene (14, 32) and trichloroethylene (33).

When interpreting these findings, limitations of the study must be considered. The study population was relatively small (1,767 marine inspectors and 1,914 noninspectors), and information on important potential confounders such as tobacco and alcohol use was not available. Although each subject's likelihood of exposure to chemicals was established, it was not possible to

identify specific chemicals. The study also has several strengths. Complete work histories were available for each subject, which provided detailed information on the tasks and duties for each position held. The use of Coast Guard officers who were never marine inspectors provided a comparison population which should minimize differences in socioeconomic and lifestyle factors such as tobacco and alcohol use.

In summary, comparison of the mortality experience of marine inspectors with other Coast Guard officers uncovered excess mortality among inspectors from cancers of the colon, liver, skin, and lymphatic and hematopoietic system, particularly leukemia, which could be related to organic solvents and other chemicals to which they came in contact while inspecting ships and barges. Mortality from cirrhosis of the liver cancer and motor vehicle accidents was also elevated. The risk of motor vehicle accidents, leukemia, and cancer and cirrhosis of the liver increased with level of exposure to chemicals, further suggesting that occupational exposures may play an important role. These results suggest that marine inspectors should take special care to limit exposure to chemicals during the performance of their inspection duties.

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Table I. Demographic Characteristics of Marine Inspectors and Noninspectors

Characteristics	Marine Inspectors		Noninspectors	
	Number	%	Number	%
Total	1767	100%	1914	100%
Year Comissioned				
< 1945	630	38%	795	44%
1945-1959	551	31%	462	24%
> 1960	493	28%	518	27%
Unknown	93	5%	139	7%
Year of Birth				
< 1910	561	32%	440	23%
1910-1929	712	40%	1020	53%
> 1930	494	28%	454	24%
Vital Status				
Alive	1234	70%	1478	77%
Deceased	483	27%	369	19%
death certificates found	451	26%	341	18%
death certificates not found	32	2%	28	1%
Unknown	50	3%	67	4%

Table II. Mortality from Nonneoplastic Disease among Marine Inspectors and Noninspectors

Cause of Death	Marine Inspectors				Noninspectors				Directly-Adjusted	
	OBS	EXP	SMR	95% CI	OBS	EXP	SMR	95% CI	Rates	Ratios
All Causes	483	608	79*	72-87	369	584	63*	57-70	118	
Infective & Parasitic Diseases	5	10	52	17-120	1	11	9*	1-51	522	
Diabetes Mellitus	2	9	23*	3-82	3	8	37	8-107	66	
Chronic Rheumatic Heart Disease	5	6	90	29-209	2	6	31	4-113	232	
Arteriosclerotic HD	172	224	77*	66-89	123	204	60*	50-72	123	
Vascular Lesions of the CNS	34	48	71*	49-99	16	37	44*	25-71	136	
All Respiratory Disease	27	38	71	47-103	19	34	55*	33-86	132	
Pneumonia	13	14	90	48-155	8	12	65	28-128	156	
Emphysema	6	9	65	23-142	4	8	48	13-124	105	
Asthma	2	2	133	16-479	1	1	81	2-451	211	
Diseases of the Digestive System	25	28	90	59-134	14	30	47*	26-80	173	
Cirrhosis of Liver	17	13	136	79-217	8	15	53	23-105	190	
Disease of Genito-Urinary System	2	10	20*	2-74	1	9	12*	1-64	188	
All Accidents	27	30	89	59-130	18	43	42*	25-66	153	
Motor Vehicle Accidents	14	13	107	58-180	9	20	45*	20-86	145	
Suicide	5	11	46	15-107	9	1	64	30-122	57	
Unknown Causes	32				28					
Number of persons		1,767				1,914				
Number of person-years		36,720				55,571				

*p<0.05

Table III. Mortality from cancer among Marine Inspectors and Noninspectors

Cause of Death	Marine Inspectors				Noninspectors				Directly-Adjusted	
	OBS	EXP	SMR	95% CI	OBS	EXP	SMR	95% CI	Rates	Ratios
All Cancer	103	117	88	72-107	66	115	75*	60-92	108	
Buccal Cavity and Pharynx	3	4	83	17-243	0	4	--	0-100	--	
Digestive Organs	34	35	96	67-134	22	32	68	43-103	171	
Esopohagus	2	3	72	9-262	2	3	74	9-268	90	
Stomach	4	7	54	15-140	4	6	65	18-167	123	
Colon	16	11	144	82-234	8	10	78	34-153	218	
Rectum	5	4	121	39-282	2	4	55	7-199	273	
Liver	3	3	112	23-326	0	2	--	0-156	--	
Pancreas	4	6	62	17-158	6	6	96	35-209	64	
Respiratory System	19	37	52*	31-81	31	39	79	53-112	58	
Larynx	1	2	57	1-317	1	2	58	1-320	35	
Lung	18	35	52*	31-82	30	37	81	55-116	60	
Skin	3	2	158	33-461	2	2	95	11-344	121	
Prostate	10	9	106	51-195	4	7	57	15-145	216	
Bladder	2	4	50	6-179	3	3	90	18-262	30	
Kidney	3	3	106	22-310	3	3	103	21-301	80	
Brain and CNS	5	3	170	55-395	5	4	136	44-317	94	
All Lymphatic and Hematopoietic Cancer	17	11	157	91-251	7	12	60	24-126	198	
Lymphoma & Reticulosarcoma	4	2	175	48-449	1	2	41	1-230	342	
Hodgkin's Disease	1	1	83	2-464	0	2	--	0-234	--	
Leukemia	7	5	155	62-319	3	5	66	14-194	199	
Other Lymphatic Tissue	3	3	115	24-336	2	3	73	9-265	165	
Number of persons		1,767				1,914				
Number of person-years		36,720				55,571				

*p<0.05

Table IV. Mortality for Selected Causes of Death By Level of Exposure
(probability of exposure X months of duration)

Causes	Exposure Level - Months									X^2 Trend
	Nonexposed			< 130			≥ 130			
	OBS	EXP	SMR	OBS	EXP	SMR	OBS	EXP	SMR	
All Cancer	98	127	77*	35	47	75	56	58	95	1.65
Colon	10	11	87	8	4	182	6	6	108	0.16
Rectum	3	4	74	1	2	60	3	2	149	0.83
Liver	0	3	--	1	1	92	2	1	153	3.47
Lung	31	40	77	10	13	74	7	18	39*	2.64
Skin	3	2	132	1	1	117	1	1	113	0.02
Brain & CNS	5	4	128	3	1	223	2	1	147	0.05
Lymphatic & Hematopoietic	11	13	88	4	5	88	9	5	171	2.29
Lymphosarcoma & resticulosarcoma	2	3	76	2	1	214	1	1	88	0.02
Leukemia	4	5	80	2	2	105	4	2	184	1.46
Arteriosclerotic HD	144	228	63*	66	88	75*	85	113	76*	1.67
Cirrhosis of liver	8	16	50*	6	6	106	11	6	186	8.99
Motor Vehicle Accident	9	21	43*	6	7	81	8	5	170	8.97
Number of Persons		2,147			1,660			791		
Number of Persons-years		58,152			20,665			13,474		

*p<0.05